# LETTERS TO THE EDITOR

*Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.*

## On the Velocity of Light

The determination of the velocity of light with the aid of mirrors furnishes some average between the velocities to and from the most remote mirror. This average may, of course, be a complicated function depending on various factors, although it seems universally assumed that the velocity either to or from the remote mirror is exactly equal to the average velocity. The recent anomalies observed by Pease and Pearson[1] in their experiments in California emphasize the need of a closer examination into these factors, among which is the structure of the light employed for such measurements.

All previous experiments have made use of light in which the incident ray and the reflected ray were essentially of the same kind, the difference consisting in the change in phase introduced on reflection. Because of this close relationship between the rays, I shall call them "related." Here, I wish to urge an experiment in which the rays are as unrelated in nature as possible and thus it is probable that the velocity obtained can be set equal to that of an unidirectional beam. The aim is to compare in a single measurement the average velocity furnished by such "unrelated" rays with the velocity of "related" rays. Should these velocities be found unequal, a greater discrimination in the definition of the velocity of light will be necessary. The possible repercussion on the theory of relativity which identifies the velocity of light with the fundamental[2] velocity of the Lorentz transformations would make the following experiment especially worth while.

A beam of light in the shape of a slit will pass through the apparatus (such as that of Foucault-Michelson) in the usual way but instead of being reflected at the distant mirror throughout its entire length, the image of the slit is to be reflected in one-half of its length at the mirror and the other half is to excite fluorescence of another color in an adjoining vessel. The comparison of the velocities consists in observing in what measure the fluorescent color is shifted with respect to the incident color in the return image.

Comments on the experiment: The time-lag in the fluorescence of numerous substances is so short that the image radiated back by the fluorescing medium will be practically as sharp as the one reflected by the mirror. The single bi-convex lens employed by Michelson in his early work may, for example, be replaced by two plane-convex lens so that one plane-convex lens can be situated close to the fluorescing material. A resonance lamp with its high efficiency may serve as the vessel adjoining the remote mirror. However, the incident and reflected rays under these conditions may not be as completely "independent" of each other as when the rays are of different wave-lengths. The time-lag of the fluorescence and the depth of penetration into the vessel, if the fluorescing medium be a transparent substance rather than a fluorescing surface, must of course be taken into account. Only such fluorescence need be used whose time-lag has been found (with the aid of the Abraham-Lemoine shutter for example) to be comparable with the time required by the mirror to rotate through the smallest detectable angular displacement and also it is to be very short as compared with the duration of the journey of the light. However, the latter errors may be minimized by carrying out the experiment with the fluorescing material at various distances from the rotating mirror.

The methods now available for constructing efficient fluorescing lamps would seem to make this experiment feasible without much further technical improvement. On the other hand, should the experiment confirm the general belief in the equality of the velocities, an experiment of this kind could determine the time-lag of various radiation processes.

SIMON FREED

Department of Chemistry,
University of Chicago,
October 19, 1934.

[1] To be published soon in the Astrophysical Journal.
[2] A. S. Eddington, *The Mathematical Theory of Relativity*, p. 19, 1923.

## Remarks on the Band Spectrum of Sulfur and the Statistics of the Sulfur Nucleus

A few years ago Naudé and Christy[1] examined the fine structure of five of the bands of diatomic sulfur in the near ultraviolet and made an analysis of them from which they calculated that in the normal state of the sulfur molecule the internuclear distance is 1.603A. If this result were correct it would appear that the sulfur molecule were very abnormal since a distance somewhat greater than 1.8A is predicted by several rules, including the covalent bond radii and an empirical rule of the author[2] by which internuclear distances can be calculated from vibrational frequencies.

Since no other deviation from these rules of this magnitude is known, it occurred to the writer to examine the data to determine whether the analysis of Naudé and Christy were unique. He soon came to the conclusion that it is not and, for several reasons, is probably incorrect. He noticed, for example, that their $\Delta_2F'$ values show certain peculiarities. They appear to be identical within experimental error for the bands 8–1 and 9–1, and also for 10–1[3] up to the point where this band runs into the head of 8–0. Now when the Naudé-Christy $\Delta_2F'$ values for 10–1 and 10–2 are plotted against $K$ they fall on straight

lines up to the point where these bands run into the heads of 8–0 and 8–1, respectively. The succeeding points deviate from these lines and follow lines with a considerably greater slope. This might be the result of a perturbation as these authors believed, but since it might also indicate that they failed to follow the branches of 10–1 and 10–2 through the regions where there is a great overlapping of lines, the data on these regions were carefully examined. It was found that the measured lines can be reassigned to the various branches in a very plausible way so that the deviation just mentioned vanishes and we obtain a set of combinations which agree for the bands 8–1, 9–1 and 10–1, and are slightly different for 8–0 and 10–2. This, together with the fact that the rotational constants obtained from these combinations are what we should expect for the ground level, is rather conclusive evidence that these combinations are $\Delta_2F''$ rather than $\Delta_2F'$ as Naudé and Christy believed.

A new set of combinations was then made to find the true $\Delta_2F'$ values. From these one finds that the rotational constants vary in the vibrational states of the upper electronic level in such a fashion that it is difficult to make an extrapolation to the vibrationless state which has great significance. Furthermore some perturbations are found in the level $v'=8$. These duplicate in the bands 8–0 and 8–1 and are additional confirmation of the correctness of the new combinations. Large perturbations are to be expected in the upper state since it has been observed[4] that many of the band heads are considerably displaced from their expected positions.

The results of the new analysis are given in Table I. An important feature is that it shows that the *even* rotational

TABLE I. *Constants of the sulfur molecule.*

| | $B(\text{cm}^{-1})$ | $D_e(\text{calc})$, $\alpha_e$, $B_e(\text{cm}^{-1})$ | $r_e$ |
|---|---|---|---|
| $v''=0$ | 0.309 | $D_e''=-2.2\times10^{-7}$ | $r_e''=1.840\text{A}$ |
| $v''=1$ | 0.307 | $\alpha_e''=0.0016$ | |
| $v''=2$ | 0.306 | $B_e''=0.309_6$ | |
| $v'=8$ | 0.230 (0.211 for $K>21$) | $D_e'=-2.4\times10^{-7}$ | |
| $v'=9$ | 0.229 | | |
| $v'=10$ | 0.239 | | |

levels are present in the ground state of the sulfur molecule instead of the odd levels as found in oxygen. Since the electronic states of these two molecules are presumably of similar character, this shows that if the oxygen molecule is symmetric in the nuclei, as has been generally accepted, the sulfur molecule is antisymmetric. However, in case the character of the electronic states has been incorrectly assigned, it is possible that the symmetry character should be reversed in both cases.

RICHARD M. BADGER

Gates Chemical Laboratory,
California Institute of Technology,
Pasadena, California,
October 29, 1934.

[1] S. M. Naudé and A. Christy, Phys. Rev. **37**, 490 (1931).
[2] R. M. Badger, J. Chem. Phys. **2**, 128 (1934).
[3] The $v'$ numbering of Naudé and Christy should be increased by one according to the results of Fowler and Vaidya, Proc. Roy. Soc. **A132**, 310 (1931).
[4] A. Christy and S. M. Naudé, Phys. Rev. **37**, 903 (1931).

**Concerning the Recovery Time of Geiger-Mueller Counters**

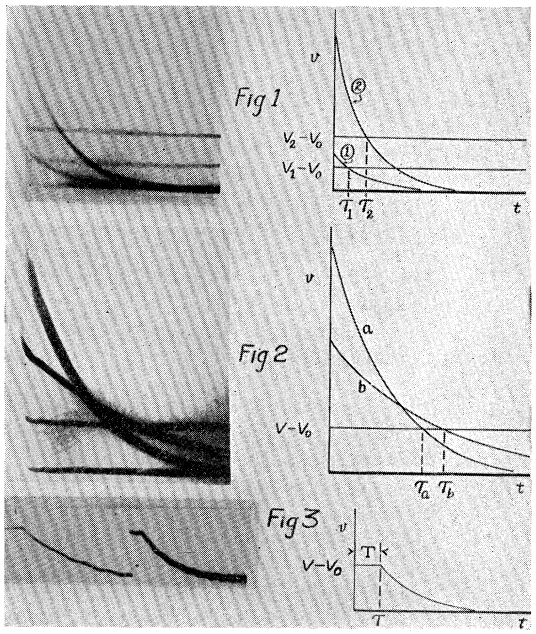
We have equipped a Braun tube with a timing "sweep" which is initiated by the phenomenon to be studied. Thus, pulses recurring at random will give retracing curves on the fluorescent screen and so may be photographed. Figs. 1–3 show three oscillograms with a schematic diagram at the right of each.

The ordinates of the curves represent the negative potential $v$ of the wire of a Geiger-Mueller counter connected in the usual way, namely, with the outer cylinder at constant (negative) potential $V$, and the wire grounded through a high resistance $R$. Figs. 1 and 2 show that when a discharge occurs, $v$ rises suddenly and then falls following an exponential curve. As one would expect its time constant is equal to $RC$ where $C$ is the total capacity between the wire and ground. Curves 1 and 2 in Fig. 1 show discharges for two values $V_1$ and $V_2$ of the applied voltage. The horizontal lines $V_1-V_0$ and $V_2-V_0$ show the excess of $V$ over the starting potential $V_0$. In other words $V-V_0$ represents that value of $v$ for which the voltage across the counter equals the starting voltage.

By suddenly applying x-radiation we have seen that a counter will discharge after $v$ has fallen below $V-V_0$ but not before. Therefore, the recovery times for the respective systems are defined by the associated time intervals denoted by the $\tau$'s in the oscillograms.

In Fig. 1 $V_2$ is greater than $V_1$, so one sees that the excess of the initial value of $v$ over $V-V_0$ increases with increasing $V$. Therefore the time $\tau$ is larger for higher operating voltages.

The two curves in Fig. 2 were taken with the same applied voltage $V$. In curve $b$ the value of $C$ was about




FIGS. 1–3.